Personal Decision Support Aids for Special Operations

Report of Syndicate One

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1.0 INTRODUCTION

1.1 Criteria

Syndicate 1 identified three criteria upon which to guide its work; the subject must be useful to NATO, it should have a counter-terrorism focus given recent events and it should produce results within 18 months. In response, a concept was developed to provide powerful improvements in capability for NATO teams of special operations soldiers, applicable to counter-terrorism and a diversity of other operational missions. The goal is to facilitate coordinated action within a small unit and to provide improved situation awareness to the individual soldiers.

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Personal Decision Support Aids for Special Operations

Syndicate One

Alward, Fricker, Hjelmstad, Kaster, Rasmussen, Steinberg, Verissimo

IST-036/RWS-005
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Criteria

- Useful to NATO
- Counter terrorism focus
- Results in short term

Counter Terrorism Cycle

- Protection
- Detection
- ***Reaction***
- Restoration

Requirements

- Navigation
- Communications
- Information (including Intelligence)
- Sensory enhancement
- Protective equipment

Sniper elimination

Equipment

- Laser range finder
- CCD image
- GPS (direction)

Functions

- 3D fused image
- Construction data
- Pathfinder/advisor
- LOS calculations
- Synchronisation

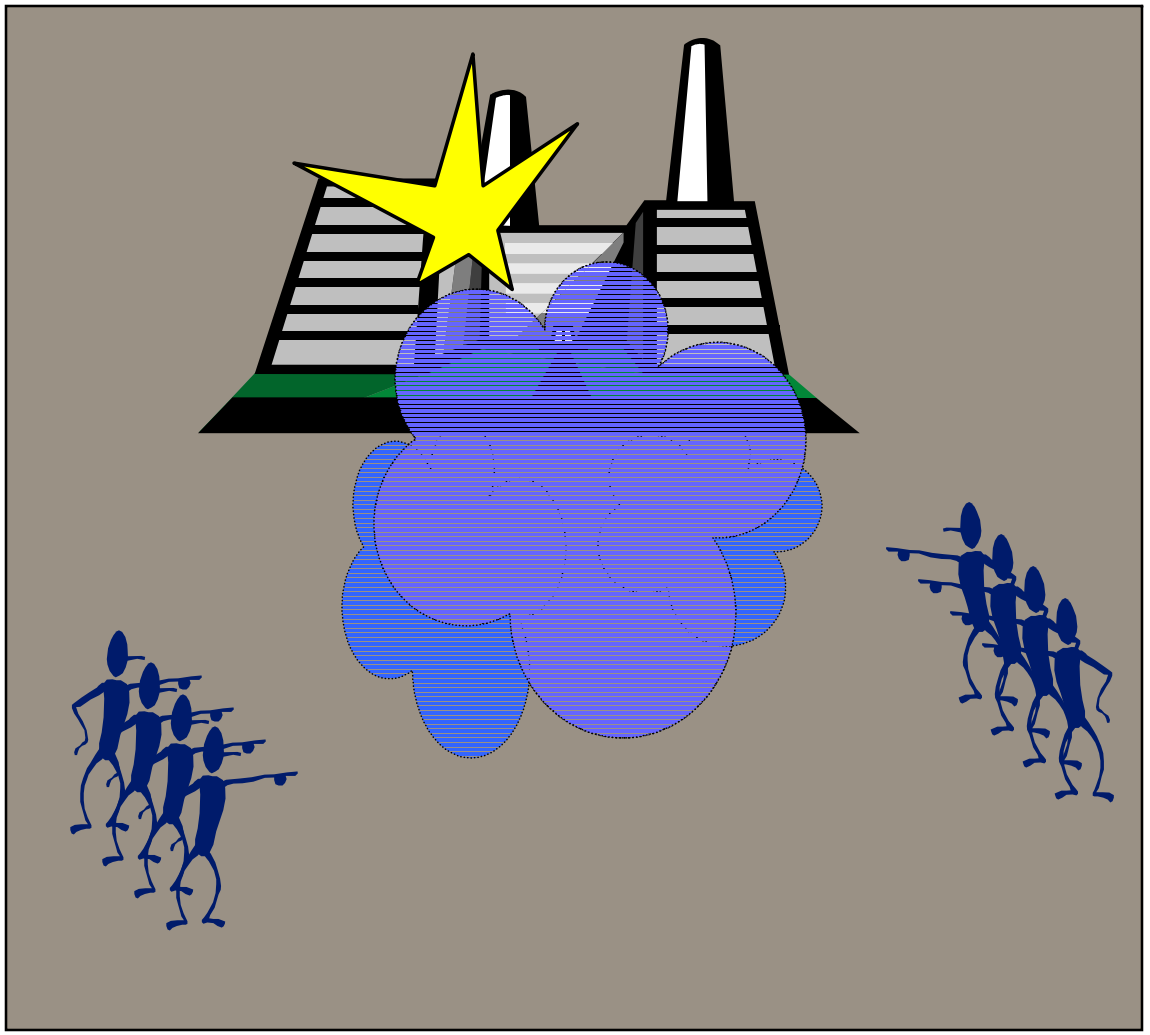
Hazardous plant explosion

Equipment

- Laser range finder
- CCD image
- GPS (direction)
- NBC sensor

Functions

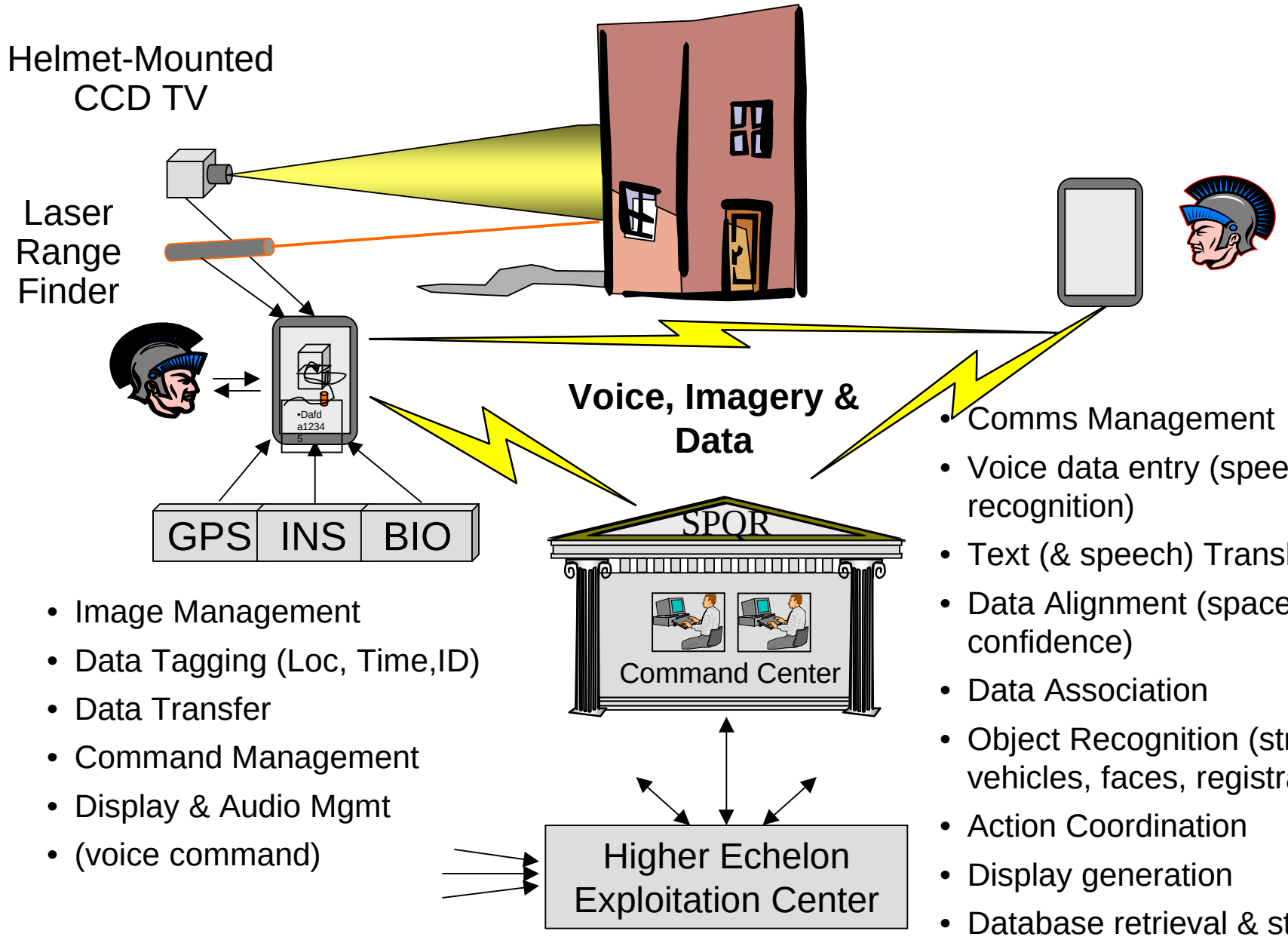
- 3D fused image
- Construction data
- Pathfinder/advisor
- Synchronisation
- Contaminant location & spread



Other Example Scenarios / Applications

- Hijacking
- Hostage
- Minefield crossing
- Civil disasters
- POW interrogation

System Concept



- Image Management
- Data Tagging (Loc, Time,ID)
- Data Transfer
- Command Management
- Display & Audio Mgmt
- (voice command)

- Comms Management
- Voice data entry (speech recognition)
- Text (& speech) Translation
- Data Alignment (space, time, confidence)
- Data Association
- Object Recognition (structures, vehicles, faces, registration #s)
- Action Coordination
- Display generation
- Database retrieval & storage

Sensors

- Initial
  - Camera
  - Range Finder
  - GPS
  - Inclinometer
  - Digital compass
  - Biometric
  - OCR
- Enhancements
  - Multi-spectral IR/Visual camera
  - Range imager
  - Directional microphone
  - Advanced navigation aids (INS)
  - RF/DF
  - NBC sensors

Communications issues(1)

- Information (data) requirements
  - Geometric Data
  - Architectural Data
  - Linguistic / Translation Data
  - Intelligence Data
  - Sensor Data
  - Biometrics Data
- Local and remotely updatable

Communications issues(2)

- EW requirements
  - EPM – Local
  - ECM and ESM through the Command Center
- Computational capacity requirements
  - Local (Individual)
  - Mobile Command Center (team)
  - Central capacity (Operational Command)

Communications issues(3)

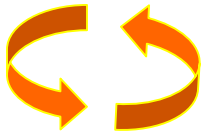
- Communication requirements
  - Duplex or half-duplex voice and data link to:
    - Team
    - Command Center
  - GPS receptor
  - Voice activated, touch sensitive screen
  - Sensor data simplex channel to Command Center
    - Biometrics
    - NBC warfare metrics
    - Multi-spectral image
    - Sound
    - Navigational (GPS, INS)

Human factors aspects in Special Ops (1)

Presentation of information:

simple
intuitive → Universal understanding → training requirements
source
compression → reliability

User oriented: adaptability



flexibility

Task oriented: goals/needs relating to task

Control: levels of automation

Communication: feedback

Human factors aspects in Special Ops (2)

Special aspects:

- **Navigation**
- Symbology/maps/graphs/text
  - Readability/consistency/uniformity/colour/texture ...
- **Communication**
- Auditory/visual
  - Voice recording/voice exchange
  - Increase trust and confidence by
    - Providing feedback
    - Clarify source of information / reliability
    - Consider absence of individual from the team
  - Prevent unnecessary distraction/task interruption
    - Minimize alerts

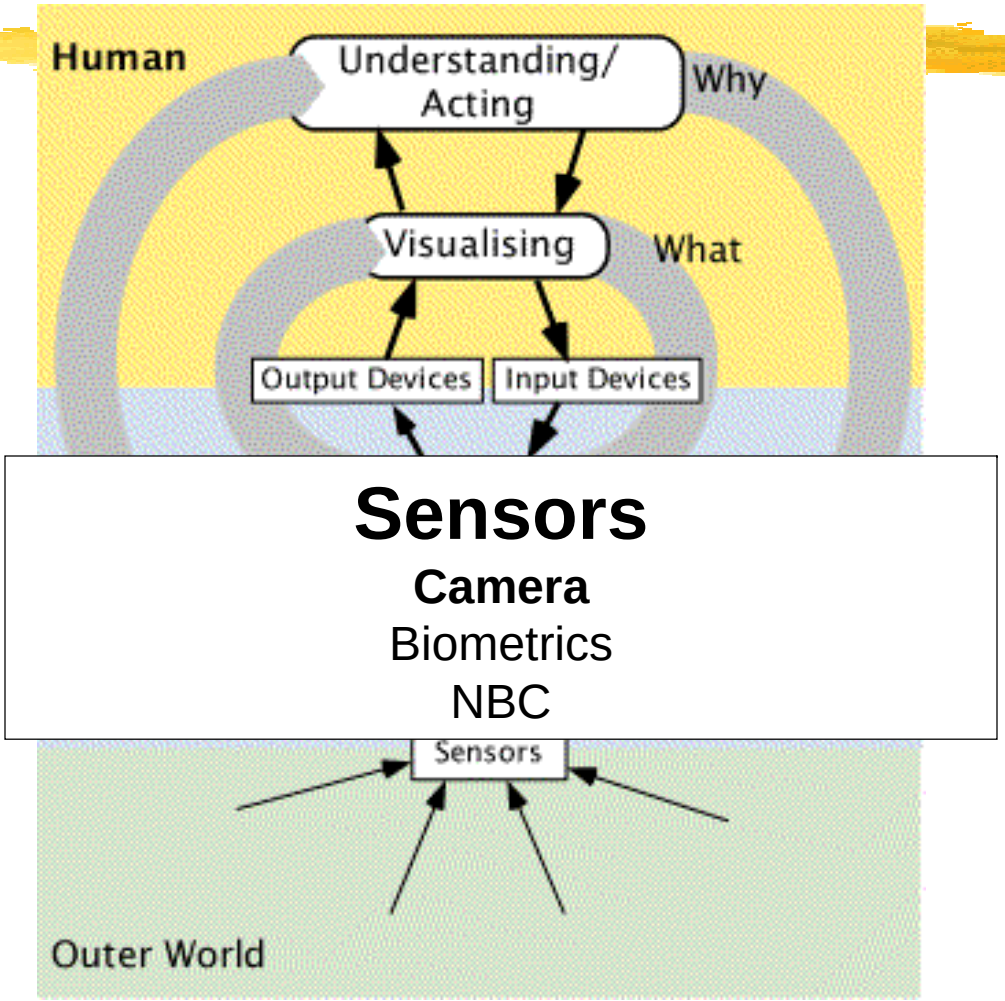
Human factors aspects in Special Ops (3)

- **Information (including Intelligence)**
  - Information compression in order to avoid overload
  - Reduction of vulnerability of the information network
- **Human sensory enhancement**
  - Facilitate perception
- **Equipment**
  - Physiological measures (Vis. aspects for the Command Centre)
  - Ergonomic aspects (anthropometrical data, visibility, reachability, colour,...)

Human factors aspects in Special Ops (4)

- Training and preparation
  - The more the HF aspects are taken into account the less training is necessary.
  - Task- and user-oriented
- Planning aids
  - Support hierarchical planning (rough/detailed)
  - Provide feedback
  - Apply heuristics
- Real-time translations
  - Provide messages/info as universal as possible
  - Provide messages/info as simple as possible
  - Individual translation if necessary

Applying the VisTG-Model



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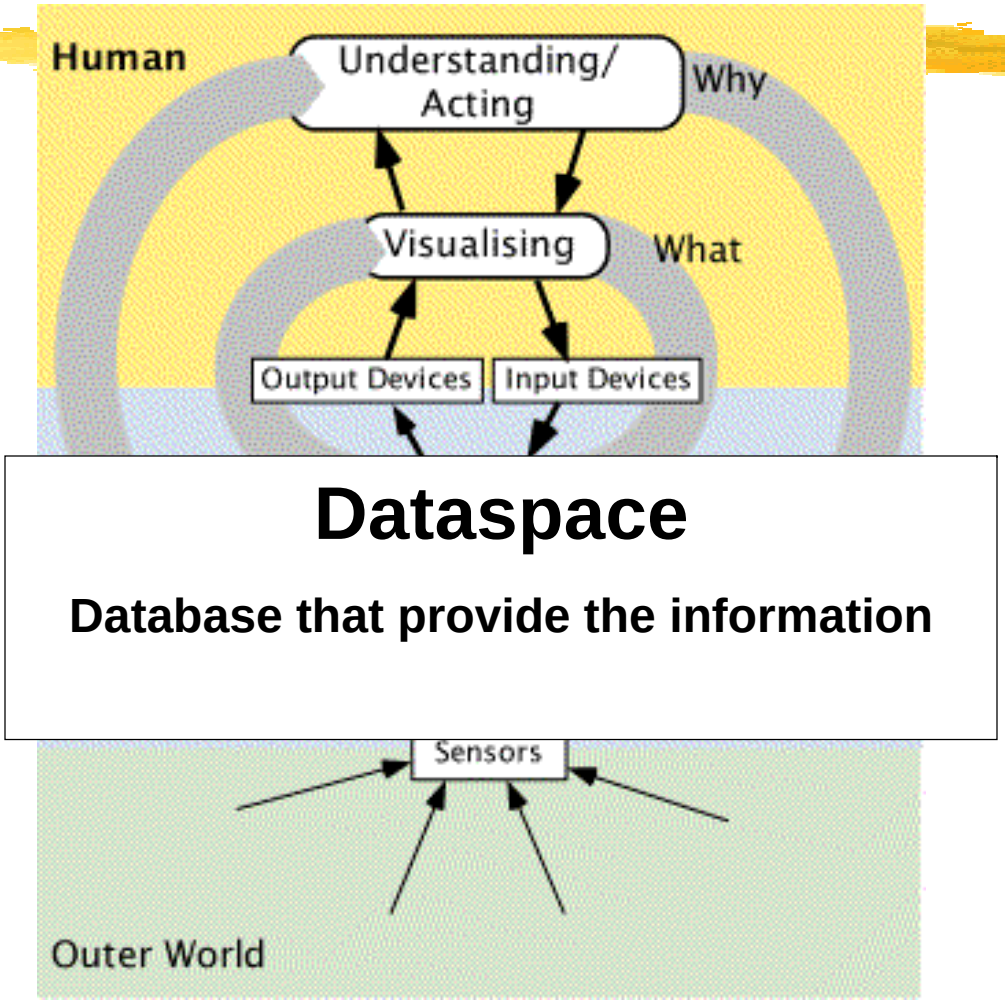

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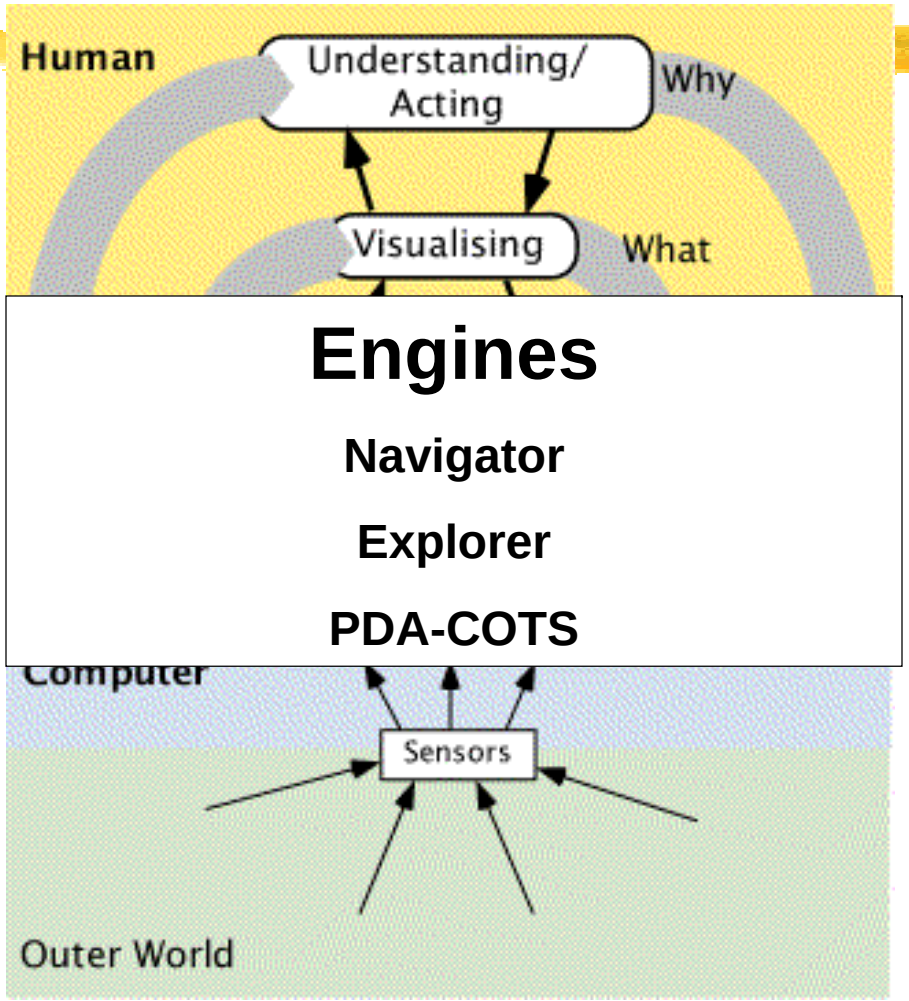

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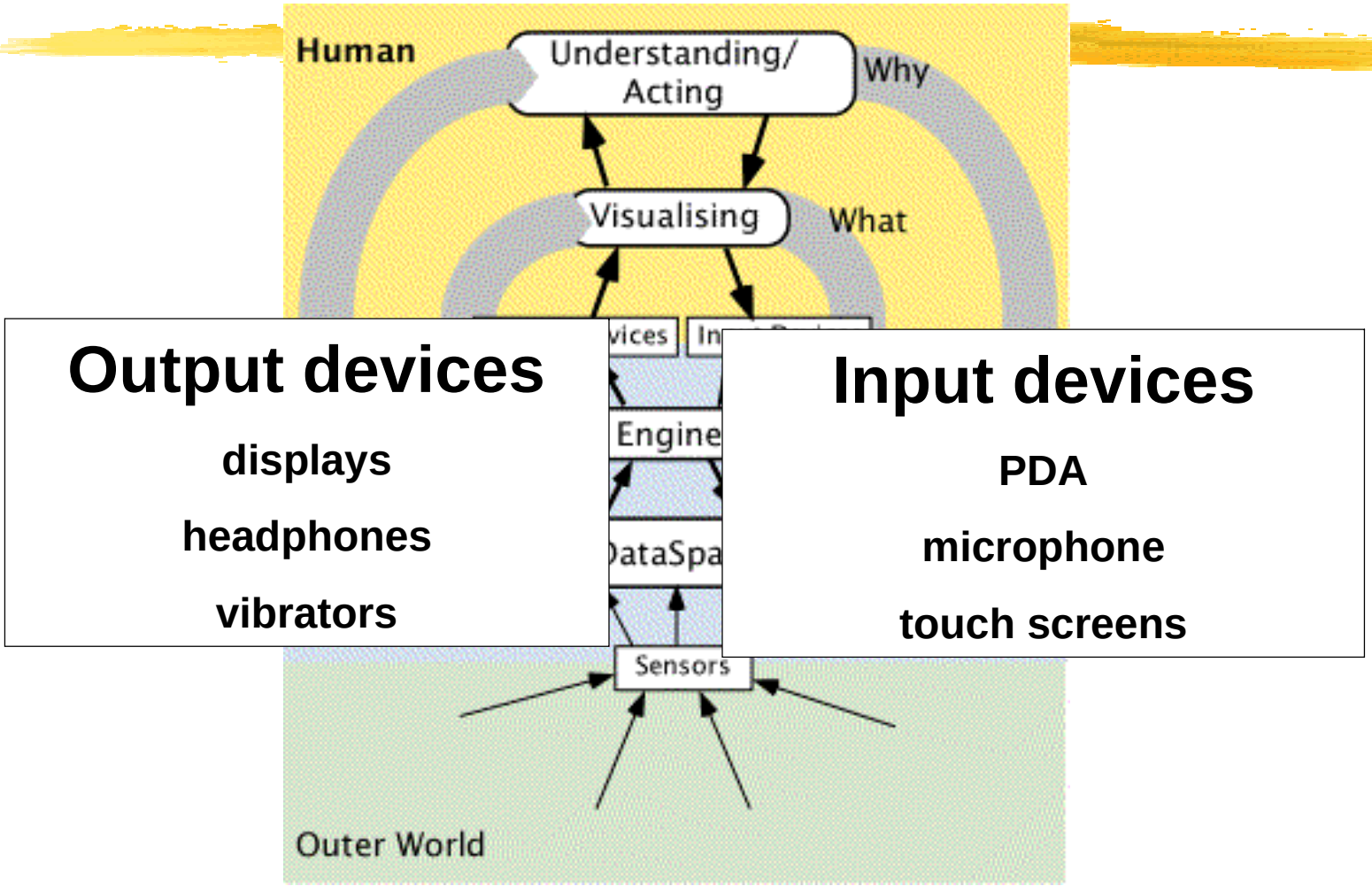


Output devices

displays

headphones

vibrators

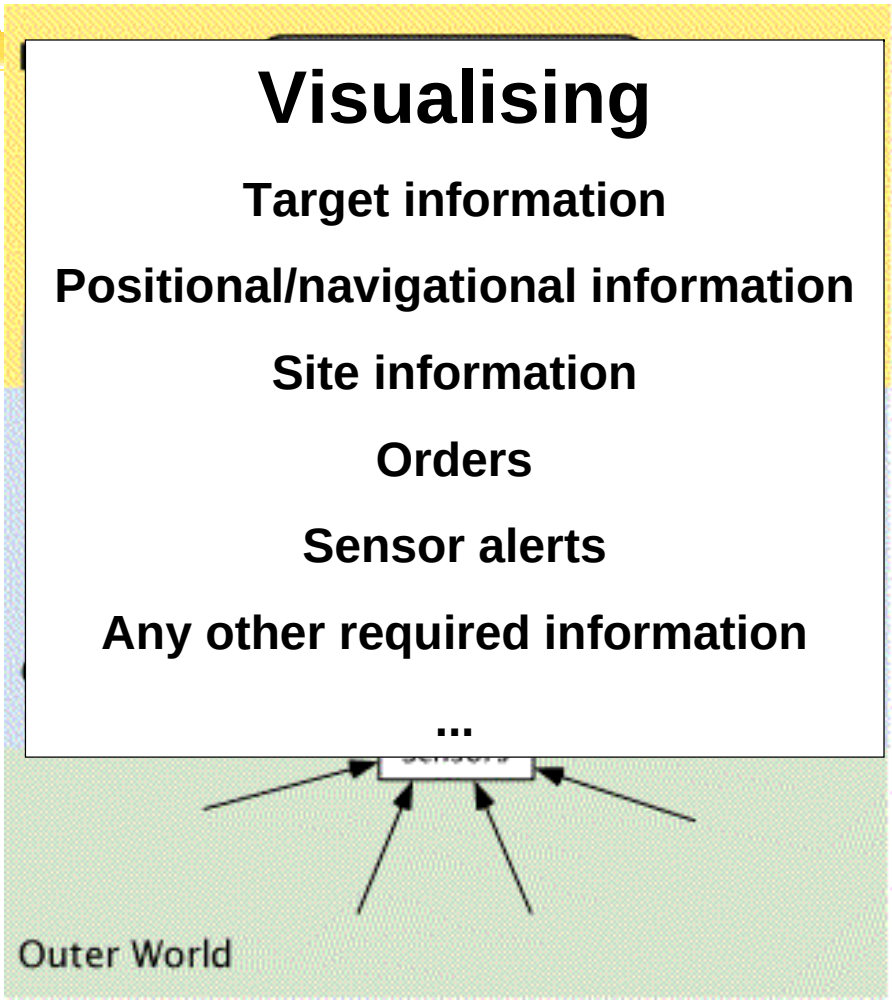
Input devices

PDA

microphone

touch screens

Applying the VisTG-Model

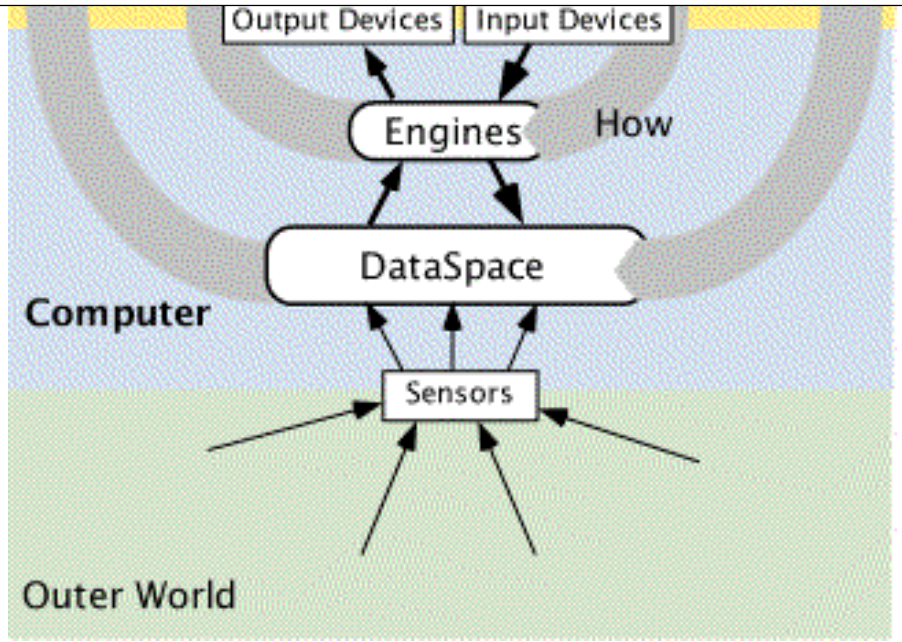


Applying the VisTG-Model

Users

Special Ops

Team leaders/Commanders



Recommendations

- Task NATO STC to develop a concept demonstrator
  - 18 months delivery
  - Commercial off the shelf products
- Form a NATO RTB Task Group to steer development

Conclusion

“Personal Decision Support Aids for Special Operations” ...

- ... offers a near-term improved capability
- ... supports evolutionary development

1.2 Counter Terrorism Cycle

The counter-terrorism cycle is comprised of four elements: protection, detection, reaction and restoration. As an example, security at an airport includes physical *protection* measures – such as fences and locked, compartmented areas – as a key component of its design, intended to reduce the risk of terrorism. *Detection* in airport security includes various aspects of personnel screening from the entrance, to ticketing, to passenger area, to aircraft boarding. *Reaction* follows detection; e.g. in the form of Special Operations personnel, highly trained and specially equipped to counter terrorists. Finally, if a terrorist act is successful, one must plan for *restoration*.

Syndicate 1 has chosen to focus on the reaction cycle and the needs of Special Operations personnel.

1.3 Requirements

We have identified the requirements of Special Ops personnel to include:

- Navigation
- Communications
- Information (incl. Intelligence)
- Sensory enhancement
- Protective equipment
- Training and preparation

2.0 SCENARIOS

Several scenarios can be provided to facilitate the discussion and visualisation of the concept.

2.1 Scenario 1: Sniper Elimination

A simple scenario is one in which a sniper has been detected and a squad-sized special operations force is tasked to eliminate the sniper. We postulate that each member of the special force is equipped with a laser range finder, a helmet mounted CCD camera and a Global Position System (GPS) receiver.

Imagine now that we have a display system as for instance a PDA in which it is possible to present 3D fused image of the data from the range finder and CCD image of all the special operations force members. The orientation and awareness capabilities of the individuals will then be considerably enhanced. As we have the position from the GPS receiver, it may be possible to obtain construction data of the building hiding the sniper from some background database. With this information available to the special operations force members together with a kind of pathfinder/path advisor and Line-of-Sight (LOS) calculations, the effectiveness of the operation can be significantly improved, with reduced risk in approaching the sniper. It may also be possible to use a wearable through-the-wall radar, which will alert the soldier to the presence of personnel and movement inside the building.

The PDA system can also be used for communication purposes, for instance for the operations centre to provide confirmation and for synchronising actions among the force members.

Equipment

- Laser range finder
- CCD image
- GPS (direction)
- Through-the-wall radar

Functions

- 3D fused image
- Construction data
- Pathfinder/advisor
- LOS calculations
- Synchronisation
- Movement detection inside buildings

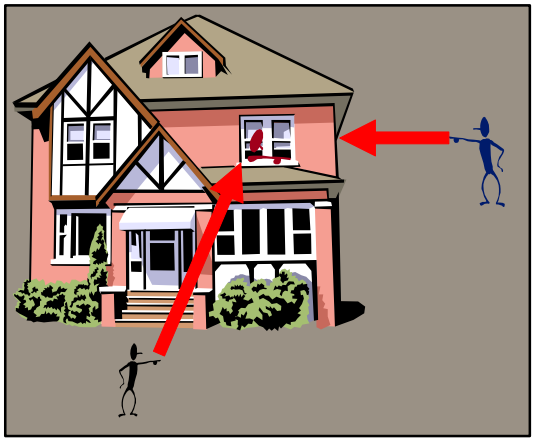


Figure 1: The Sniper Elimination.

2.2 Scenario 2: Hazardous Plant Explosion

The special operations force from the sniper scenario above can handle other tasks quite different from sniper elimination with a modest addition of more equipment.

Consider a case of a situation in which special operations soldiers are tasked to respond to an explosion within a hazardous plant, whether it was just an accidental explosion or the result of a terrorist attack. If NBC sensor equipment is added to the soldiers' equipment, they will be much better capable of assessing the situation and responding in an appropriate and coordinated manner. With the fusion of the data from the imaging, range-finding and NBC sensors, it is will be possible to show the density of the contaminants on a digital map and thus enabling the response team to avoid the most dangerous areas.

Equipment

- Laser range finder
- CCD image
- GPS (direction)
- NBC Sensors

Functions

- 3D fused image
- Construction data
- Pathfinder/advisor
- Synchronisation
- Contaminant location & spread

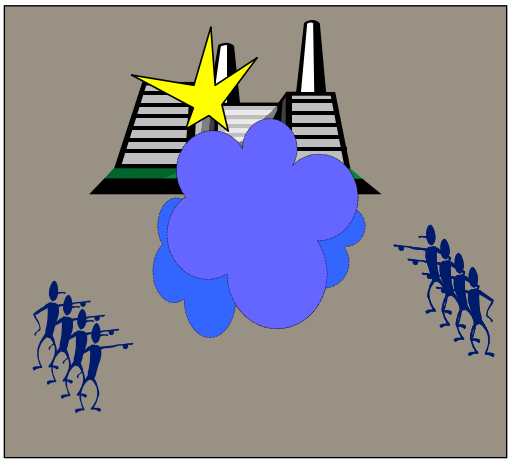


Figure 2: Hazardous Plant Explosion.

2.3 Other Scenarios/Applications

Yet other examples of tasks can be handled by the special operations force with no or only modest additional equipment and functionality: Response to Hijacking or Hostage situations, Minefield crossing, civil disasters or POW interrogations, just to mention few. The last example, POW interrogation, can be easily performed by a member of the special operations force if the functionality of his display system is enhanced with a speech recognition/automatic translation function, whereby the recognition/translation process can be performed at a more powerful computer at headquarter.

3.0 SYSTEM CONCEPT

A concept was developed to provide such powerful improvements in capability for individual special operations soldiers (Figure 3). The goal is to facilitate coordinated action within a small unit and to provide improved situation awareness to the individual soldiers.

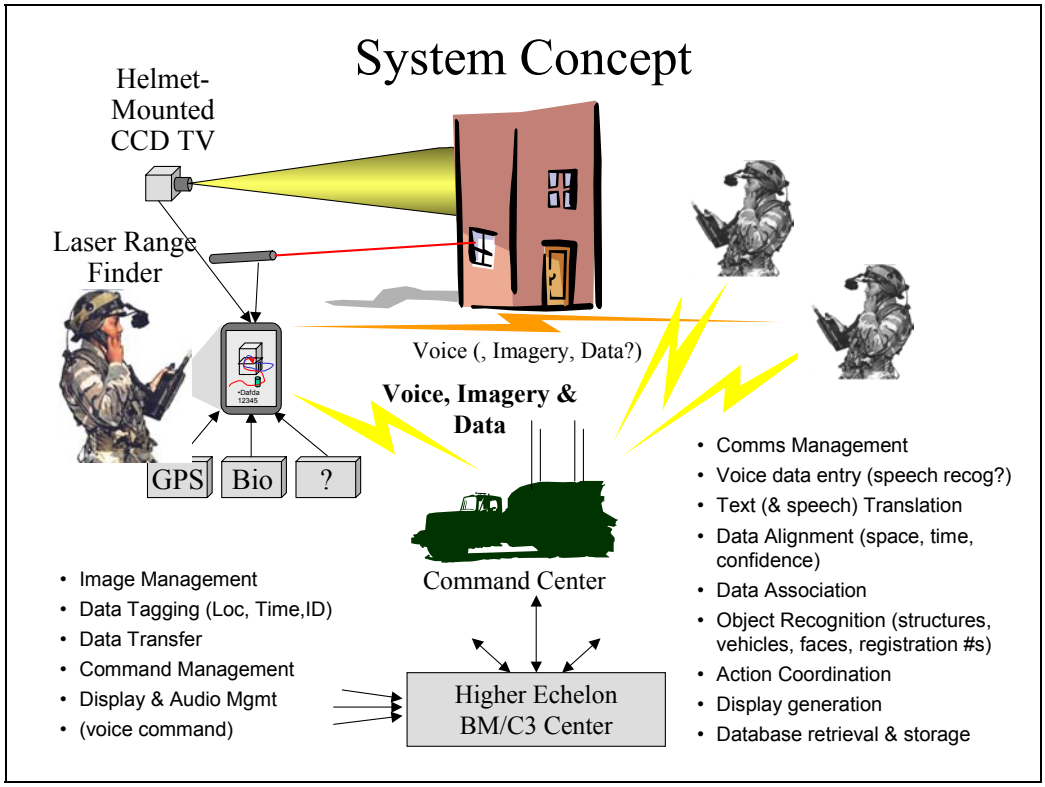


Figure 3: The System Concept.

The premise is that NATO special operations forces typically will be operating in teams, in radio communications with a mobile or deployable command centre. This provides opportunities for sharing information, maintaining a consistent situational awareness and coordination among team member. It also allows much sophisticated information storage and processing to reside at the command centre, reducing the need for the dismounted soldier to carry heavy, power-consuming equipment.

The individual soldier would be equipped with a minimal set of light-weight, portable, rugged sensors. An initial configuration can readily be built from commercially-available, inexpensive components (possibly requiring ruggedization). These can include a CCD television camera integrated with a laser range finder, miniaturized GPS/INS and possibly biometric sensors. Processing, display and voice/data

communications can be performed by a standard Personal Data Assistant (PDA), given that the bulk of processing can be performed at the command centre. Enhancements in sensing, navigation and PDA functions can be incorporated as capabilities in these areas become available.

Even the minimal, initial configuration, would provide special operations units a powerful capability improvement. A team of soldiers would be able to share imagery and full three-dimensional views (provided by the pixel-level fusion of 2D TV imagery with laser ranging). Integration of such data among team members and with data from other sensors and databases (terrain, cultural maps, building plans, red/blue force deployment, etc.) would be performed at the command centre and provided to team members by voice or touch-pad request. The PDA display can be used to indicate ingress/egress routes, status of team members and of the tactical situation. Audio can provide alerts and aid in coordinating team action.

The command centre, involving one or more laptop workstations, supports the soldiers in the field with:

- Managing communications with team members and with external entities (other command centres, higher-echelon command and intelligence centres, etc.);
- Voice data entry (possibly to include speech recognition);
- Text (& possibly speech) translation;
- Spatio/temporal data alignment;
- Assigning and maintaining confidence of various information sources and data sets;
- Associating data received from team members, from external sensors, sources and databases;
- Object Recognition within the data from team member (structures, vehicles, faces, registration numbers, etc.);
- Coordinating team action;
- Generating displays for command post analysts and for transmission to team members;
- Database retrieval & storage.

4.0 INPUT/OUTPUT-DEVICES AND SENSORS

Like communications, input and output devices are a serious concern of the system, in that the flexibility and operability of the system depends mostly on these three aspects. On the other hand the plug-and-play input and output devices here enumerated can easily be changed depending on the scenario.

4.1 Input Devices

- **Voice activated control:** To operate the system and initiate communications.
- **Touch sensitive screen:** To operate the system.
- **Pencil shape scanner:** Input for written material.
- **Multi spectral camera:** Visual input device, image enhancer.
- **Laser Range Finder:** Target range assessment; common data registration.
- **Microphone:** Permitting voice communications and alarms in normal mode.
- **Morse Key or SMS (12 key keyboard) (silent mode):** Communications in silent mode.
- **GPS receiver:** Geographical data and common data registration.
- **Storage reading device (e.g. DVD or flash memory):** To maintain consistent real-time databases.

4.2 Output Devices

- **Headphones:** For: team communications, microphone amplification and real-time translation.
- **Intelligent helmet and/or wrist PDA screen:** A visual interface that frees the fighter hands to handle a weapon.
- **Signalling vibrating device:** Signalling system alarms or information arrival.

4.3 Sensors

An initial set of sensors to be integrated with the special operational soldier's equipment can include:

- **CCD camera (still & video, visual band)**
- **Laser Range Finder**
- **Digital compass**
- **Biometric sensors (for status indication, user ID, medical triage)**
- **Optical Character Reader (for document, sign translation via command centre)**
- **GPS Receiver**
- **Accelerometers**

Commercial units of these types are available for immediate proof-of-concept testing. Some have been militarized. Such testing would be followed by an engineering effort to select the appropriate technologies, adapt and package components for battlefield operations.

Enhancements will be determined by the evolving military requirements, CONOPS and technology maturation. Among feasible enhancements in the near-terms are the following:

- **Multi-spectral IR/Visual camera**
- **Range imager**
- **Directional microphone**
- **Advanced navigation aids (integrated GPS/INS)**
- **Radio Frequency Direction Finding (RF/DF)**
- **Integrated Nuclear, Biological and Chemical (NBC) sensor**

Also the system might take advantage of recent developments in light-weight radio frequency sensors, which might be helmet mounted. This can be implemented as a ***Radio Frequency Awareness Sensor (RFAS).*** Functions to be provided may include:

- Passive RF sensor that intercepts comms transmissions in HF, VHF and microwave bands, provides direction finding, triangulation, classification, threat analysis and comms intercept;
- Sensor function utilizing remote transmitters/transmitters of opportunity for close up MTI function and medium range situation awareness (10-200m);
- Sensor function utilizing mm wave integrated transmitter for close-up mapping and target detection (0-100m).

5.0 COMMUNICATIONS AND INFORMATION SYSTEMS

This section briefly describes the specific CIS requirements for coordinating a Special Ops team combating terrorism.

5.1 Information/Data Requirements

With recent improvements in technology, the availability as well as the need for information has increased. Today we are able to supply to the soldier the needed information/data for a safer and quicker operation directly and real-time. The following types of information that will need to be communicated to achieve the proposed concept:

- **Geometric Data:** Needed for better assessment of the operational area's environmental aspects.
- **Architectural Data:** As the previous it gives the soldier knowledge to operate on urban areas or fighting targets placed on buildings.
- **Linguistic / Translation Data:** Needed to get real-time translations of conversations or to understand written documents.
- **Intelligence Data:** To include any other data that can support the mission accomplishment regarding, for example, the characteristics of the enemy or suspicious material.
- **Sensor Referential Data:** This information, like the referred on the next point will supply to the fighter, for example, reference values regarding personal safety and triggering alarms. (e.g. IFF, exposure to NBC agents, etc.)
- **Biometrics Referential Data:** Personal safety issue. Needed for the assessment of personal fighting capacity.
- **Local and remotely updateable data:** As the need, nature and source of information can change during the mission, data requirements can change as well, and regarding this the system has to have the availability to be updated on user request or by the command centre.

5.2 Electronic Warfare Requirements

A personal system like this must address EW issues to ensure the robustness and security of the system and to increase fighting capability. EW provisions of the system must include the following:

The individual soldier's equipment should have integral EPM (Electronic Protection Measures) and possibly could include ESM/Direction finding sensors:

- **EPM:** Minimize the electromagnetic signature of the system, high-speed transmission and low power.
- **ESM:** Medium range electromagnetic source detector.

The Command Centre could provide signal and data processing to support ESM (Electronic Support Measures) and could provide ECM (Electronic Counter Measures) capabilities as well:

- **ESM:** The use of Direction Finding information from multiple personnel equipment will help to build a scenario picture and to detect and locate targets.
- **ECM:** A limited capacity, e.g. to avoid the enemy use of wireless systems, could be provided at the command centre.

5.3 Computational Capacity Requirements

In assessing the data processing and storage requirements, the system is envisioned as operating either as stand alone or integrated in a network. Since portability has its costs regarding weight and power consumption, the system in a stand-alone version would not have all the resources needed (mainly storage capacity), which can be solved when integrated in different level network. Functions to be performed include the following:

Local (Individual Soldier)

It should control the sensors and communications. It needs limited storage capability, low power consumption and to be physically simple and robust.

Mobile Command Centre (Team)

It is the intermediate level of processing. It should process information from several individual systems (data fusion). It should be able of operating remotely an individual system. It can be placed in a vehicle.

Central Capacity (Operational Command)

A backup system located at an operational command and can be as large and powerful as necessary.

5.4 Communication Requirements

Two different needs have been considered in specifying the communication requirements. Voice communications among team members and between the team and command centre tends to be essential for operational coordination. Therefore, team link requirements need to be particularly careful about emitted power.

On the other hand, data links between individual soldiers and the command centre can use new spread spectrum multi-hopping technologies that more efficiently use the spectrum and are more difficult to detect or locate.

As we have considered this system as an evolutionary system, COTS with TETRA standards could be used in early/test versions.

Duplex or half-duplex voice and data link to:

- **Team** Operational coordination; multimedia information exchange.
- **Command Centre** Operational coordination; voice / data situation report; receive / acknowledge orders, etc.

Sensor data simplex channel to Command Centre

- **Biometrics** Reports fighter health vulnerabilities.
- **NBC warfare sensors** Reports NBC agent's concentration or threat.
- **Direction Finder** Transmits information about electromagnetic sources.
- **Multi spectral image** Transmits operational theatre multimedia visualization.
- **Sound** (Like previous).
- **Navigational (GPS, INS)** Reports positional coordinates.
- **System Power alarm** Reports system autonomy.

6.0 HUMAN FACTORS ASPECTS IN SPECIAL OPERATIONS

6.1 General Aspects

This section briefly introduces the main human factors elements that should be considered in the design of equipment to be used by the Special Ops individuals.

Fundamental to aiding the understanding of the soldier in the field, *information* needs to be presented in a mode that aids perception. Information that can be visualised should be presented in a simplistic and intuitive way. In the environment in which the solider is likely to be operating, influences of environmental factors affecting an operator's performance should be attenuated as far as possible. By use of presentation formats that promote universal comprehension, information should be accessible to all parties involved in NATO operations. It should also be noted that if a universal ease of understanding is captured, training requirements for comprehension of information should be reduced. This will be a valuable time-saving factor in introducing the product to operational forces.

Information provided to special ops personnel needs to be reliable for an operator to place his/hers trust in carrying out the task at hand. This issue should be dealt with at the command centre level and only information deemed dependable should be exported. Compressing the information at the command centre level will also prevent the operator from becoming overloaded with information that is not necessarily pertinent or of value to the mission.

The process for designing the decision aid for Special Ops, needs to be both user- and task-orientated. By ensuring that the development occurs considering user and task attributes, the tool's adaptability and flexibility will be enhanced. The system will meet not only the goals of the individuals, but also the needs relating to the task.

To facilitate the ease of *control* on the system, levels of automation can be compiled prior to the operator entering the environment. If the task environment is likely to involve constraints to the operator's effectiveness, levels of automation could be set to a higher degree than if the environment was perceived as less demanding.

Feedback is an essential process that needs to take place between all parties and all stages of the operation. By ensuring that feedback transpires throughout the *communication* chain, the special ops soldiers and command staff will be kept well informed.

6.2 Further Applicability to Special Ops

Additional special aspects of *information presentation, communication* and *sensory enhancement* must be considered in designing equipment for Special Ops (per Special Ops, Ch. 1.3). Among such factors are the following:

In order to make an information network as robust and survivable as possible, the manner in which information is presented should be limited to presenting only salient information. This compression of information should reduce the risk of a system failing due to overload. Information sources should be compiled to allow for incomplete and partly inconsistent data. If a system is to deal with inferior quality reports it should not cause network damage or break down.

Communication generally occurs on auditory and visual channels. Voice recording and voice exchange play a major role. The above mentioned need for an increase in confidence of the individuals and the reliability of the provided information by feedback, as well as clarification of the source of information, should also take into account scenarios where individuals are absent from their team members and self-responsible. They therefore need particular support while in mission.

In order to facilitate task performance of the individual Special Ops soldiers, unnecessary distraction and task interruption should be prevented as far as possible. Alerts should only be issued if essential to the task in hand.

Navigation support can be carried out in various ways. Besides auditory instructions, visual aids in form of appropriate maps, graphs and textual information/symbology should be displayed on each individuals' PDA. Ergonomic characteristics like readability, consistency, uniformity, adequate colouring, texture, etc. should be taken into account.

When designing the individual soldier's *equipment,* the environmental situation has to be considered. The clothing has to be weather-proofed, be appropriate in regard to anthropo-metrical data, visibility, reachability, movement requirements in general, etc. Physiological data should be transferred to the command centre in order to react in critical situations like illness of, dizziness of and danger for the individuals.

Considering *training* and *preparation* issues for the Special Ops individuals, the importance of the user- and task-oriented design of the equipment must be emphasized. The more the aforementioned human factors elements are taken into account the less training and preparation is necessary. As a matter of course adequate training is inevitable. However, by incorporating ergonomic principles into the design of equipment and tools aids the minimization of effort needed whilst still optimizing task performance.

The individual soldiers and command centre personnel have to be incorporated in the *planning process* for a Special Ops mission. Hierarchical planning, i.e. from rough to detailed has to be supported. Feedback ought to be provided at any single step in the planning process. Database applications and expert systems should be employed to optimize the mission preparation and to support the mission planer as well as the Special Ops individuals. Heuristics might be applied in order to increase familiarity and confidence in the task.

Last but not least, the aspects of understanding/communication in terms of *real-time language translation* have to be considered. Messages back and forth between command centre and individuals should be as universal and as simple as possible. Individual translation facilities might be employed where necessary.

6.3 Applying the VisTG-Reference-Model to Special Operations

The organisers of this workshop, the IST021-RTG007: "Multimedia Visualisation of Massive Military Datasets", have developed a Reference Model for visualisation (*RTO TR-030*). In order to emphasize the importance of visualisation aspects in the Personal Decision Support Aids for Special Operations the various issues for visualisation have been represented in the model.

Figure 4 extracts the core human and computational elements central to the visualisation process. The most important feature of this model is that "Visualising" is something that happens inside the human mind, in support of the human's understanding of a world of data. The data may reside in a machine but they ordinarily represent states and processes in an outer world of interest to the human.

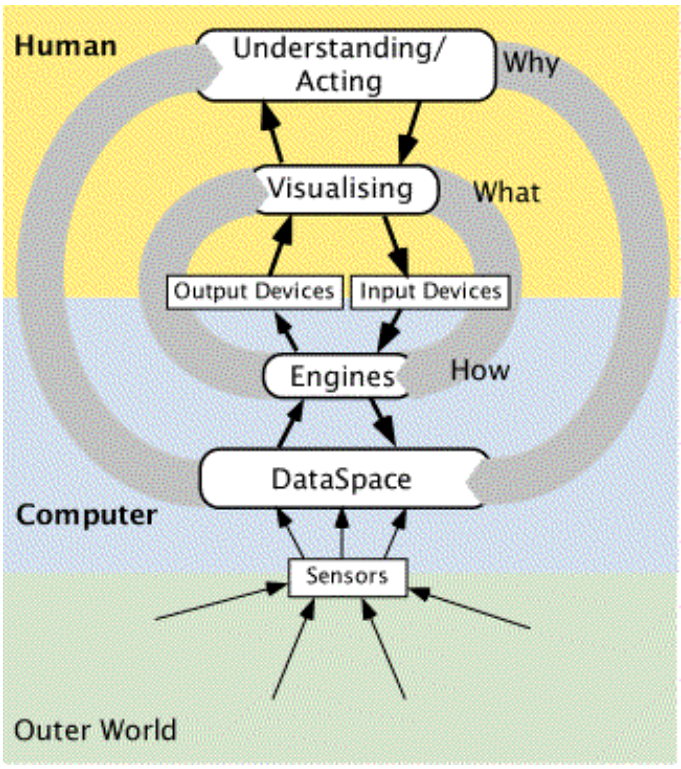


Figure 4: The VisTG-Reference Model.

Visualisation is a human process supported by a corresponding set of processes inside the machines, which are generically called "Engines". Engines communicate with the data in the data space, selecting, manipulation, and perhaps modifying it. The results of the work of the Engines are communicated to Presentation systems, which in turn prepare the data from the Engines for presentation to the user through the physical input/output devices. The Presentation systems also allow the user to communicate with the Engines to determine how they interact with the data space. The machine engine processes and the human visualisation processes communicate through Input and Output (I/O) Devices, which we take to include not only the physical devices, but also all the interaction processes involved with their control and use.

For the Special Ops the model components apply as follows:

- ***Sensors*** are, e.g. camera, Biometrics, NBC, as in Chapter 4 listed.
- The ***Data space*** is comprised by all the information sources stored in the various databases involved in the Special Ops environment.
- The ***Engines*** are Navigators, Explorers, PDA-COTS, etc. that process and provide the information to the users.
- ***Output devices*** are among others displays, headphones and vibrators, whereas ***Input Devices*** are PDA, microphones and touch screens.

All the environmental and operational data have to be represented for ***visualising*** by the human, such as target information, positional and navigational information, site information, orders, sensor alerts and others.

The human who has to ***understand*** and ***act*** according to his mission is the Special Ops individual and certainly the team colleges, team leaders and the commanders.

7.0 RECOMMENDATIONS AND CONCLUSIONS

Syndicate 1 recommends the IST staff this report in the form of a tasking. Specifically:

a) NC3B might develop a concept demonstrator based on the use of COTS with an 18 months delivery date; and

b) A NATO RTB Task Group could be formed to steer development.

In conclusion, the proposed **"Personal Decision Support Aids for Special Operations"** project:

a) Offers a near-term improved capability; and

b) Supports evolutionary development.

8.0 REFERENCES

RTO TR-030: *Visualisation of Massive Military Datasets, Human Factors, Applications and Technologies*, Final Report of IST-013/RTG-002 submitted by the members of IST-013/RTG-002 for the RTO Information Systems Technology Panel (IST), May 2001.

SYMPOSIA DISCUSSION – SYNDICATE 1

Question:
Information security is a concern, what if a node is taken over by the enemy?

Response:
There are electronic protection measures that can be taken to minimize the possibility of happening, such as jamming cell phones. Biomedical sensors could also indicate if equipment was removed.

Comment:
COTS might be a good option for a prototype, but proprietary equipment may be necessary for implementation.